Continuously Enlarging The Solar Energy Utilization

—Beijing Solar Energy Research Institute
—Beijing SUNPU Technical Company
—National Engineering Research Center
for Renewable Energy

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1. Introduction

Renewable energy utilization has grown so rapidly in recent twenty years that just a few new and high technology can compare with it, such as computer, Internet. More and more people recognize the importance of finding a clean and sustainable energy to solve the energy shortage and serious environment pollution. Like the whole world, China develops the renewable energy utilization continuously in order to change the energy structure and environment appearance, to satisfy the urgent request in the area of lacking of energy and electricity.

Beijing **S**olar **E**nergy **R**esearch **I**nstitute, as the largest domestic institution of the solar energy field in China, which was established in 1979, there is over 230 staff, main R&D and industrialization activities include solar thermal, photovoltaic, and efficient conservation.

Over 200 outstanding achievements have been made in BSERI. In the solar thermal, there are various flat plate solar collectors, passive solar houses, solar drying and solar thermal water pumps etc; the recent development effort has been transferred to the usage of higher temperature working fluid, for example, the development of the evacuated-tube heat-pipe solar collectors. A series of selective absorptive coatings, such as Al anodized coloring, magnetron sputtering selective coatings, anti-reflective coatings, and silver paste technology for solar cell manufacture have been

developed in the field of solar energy materials. Various solar cells have been researched and developed.
Beijing **SUNPU** Technique Company is the daughter company of BSERI , set up in 1988. The main goal of the company is to promote the commercialization and marketing of renewable energy products based on the R&D achievements of BSERI. A marketing network spread out in whole country. Significant economic benefits increase greatly year by year, yearly general sales reached up to 200 million yuan RMB.

In order to accelerate the development of engineering popularization and industrialization of renewable energy application, China **M**inistry **o**f **S**cience and **T**echnology chose BSERI as the backing unit, setting up the **N**ational **E**ngineering **R**esearch **C**enter for **R**enewable **E**nergy in 1992. The center chose the industrialization of solar thermal and solar PV as the main objectives.

To reach the objective of the large scale utilization of solar cells, also support the NERC for Renewable Energy, Beijing Municipal Commission for Science and Technology chose BSERI as backing unit, setting up **B**eijing **R**esearch and **D**evelopment **C**enter for **S**olar **P**hotovoltaic **T**echnology.

2. Solar Photovoltaic

2.1. R&D:

BSERI represents the highest level in the domestic PV R&D activities level in China, especially, in the solar cells based on silicon material. In order to improve conversion efficiency and reduce cost of solar cells to reach the goal of large scale terrestrial application of solar cells, since 1992, the R&D of high-efficiency silicon solar cells have been carried out in BSERI, including:

a. **I**nverted **P**yramids texturing & **S**elective **E**mitter (IPSE) solar cells, the structure of the solar cells is shown in Fig.1. The best efficiency is showing in the table

(AM1.5, 25℃):

Voc(mV)	Jsc(mA/cm^2)	FF(%)	η(%)	Area(cm^2)
656.1	37.4	0.806	19.79	4.04

b. **L**aser **G**rooving for **B**uried **C**ontact (LGBC) solar cells
Compared with IPSE solar cells, the process of LGBC solar cells are much simplified, the structure is shown in Fig.2. The characteristics are shown in following table.

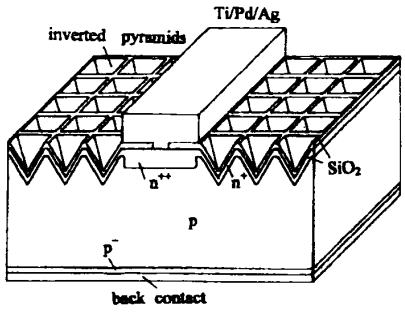
(AM 1.5, 25℃):

Si wafer	Voc(mV)	Jsc(mA/cm^2)	FF(%)	η(%)	Area (cm^2)
FZ	663.8	34.84	80.58	18.6	25
CZ	622.9	34.88	79.27	17.22	25
SG	622.1	35.24	78.74	17.26	100

c. Multi-**c**rystalline **S**i (mc-Si) Solar Cells
Based on R&D of IPSE & LGBC, the mc-Si wafers of Bayer Solar were used in the experiment. The phosphorus gettering technology was used in the manufacture process.

(AM1.5, 25℃)

Voc(mV)	Jsc(mA/cm^2)	FF(%)	η(%)	Area(cm^2)
595.0	34.23	0.7129	14.53	1.0
592.1	30.1	0.7015	12.5	100



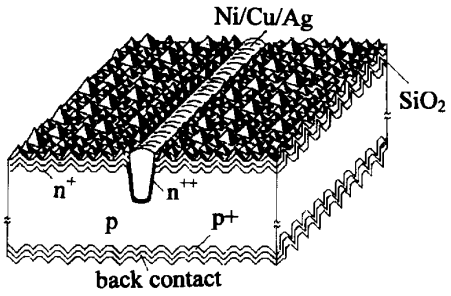


Fig.1. the structure of IPBE Fig.2. the structure of LGBC

d. Poly-Si Thin Film Solar Cells

Poly-Si thin film solar cells have a great potential of reducing cost, therefore, the R&D of the community of photovoltaic in the world has focused this topic considerably. The rapid thermal Chemical Vapor Deposition (RTCVD) is used to manufacture Poly-Si thin film solar cells in BSERI.

(AM1.5, 25℃)

Thin Film Solar Cell	Voc(mV)	Jsc(mA/cm^2)	FF(%)	η(%)
On the inactive Si wafer substrate	626.4	30.46	0.7788	14.86%
On the non-Si Substrate	614.5	30.46	0.6697	9.32%

BSERI will continue R&D of new process, material and technology that can reduce cost of solar cell by large extent, R&D of industrialization technology of high efficiency and low cost cells. All of these will make the level reach or close advanced level.

R&D of PV power generation application technology, including utilization system CAD, grid-connect technology, cheap & efficient invert(single or three phase), controller, and solar PV pump etc.

2.2. Industrialization

A pilot line of high efficiency solar cells with 500 KW capacity was set up in 1997. The best efficiency of 10×10 cm^2 is 17.26% , average efficiency is over 15%.

Because of large extent rise of request for the solar cells, BSERI will set up an 1 MW high efficiency solar cell production line with the average efficiency≥15% by the end of 2001, a 5 MW production line with efficiency≥16% by end of 2005□

2.3. PV application

The development of PV power generation systems has been proceeded in BSERI, such as PV systems for microwave relay station, optical fiber communication systems for communication, having designed and produced various solar home system for the household in the Northwest area of China, also off-grid PV power plants for the geological exploration etc..

3. Solar Thermal

The priority in solar thermal utilization is laid on low temperature utilization, such as solar water heaters, passive solar houses. Solar thermal utilization technology is much mature in BSERI.

3.1. Solar Collectors and Solar Water Heaters

The first flat plate SWH production line was set up in 1987, the the yearly quantity is about 300,000 m^2, the products are sold briskly in the whole country. Various and different SWH and systems have been developed, such as anti-freezing type, bi-loop type etc., so that they can be used in the north area in the winter.

Experienced the R&D phase, BSERI & NERC developed the industrialization technology of evacuated tubular heat-pipe solar collectors in the early of 1990's. Based on this technology, BSERI with Daimler Benz Company of Germany set up the Joint Venture in 1996, Beijing SUNDA Solar Energy Technology Co. Ltd., which can produce 500,000 tubes each year, almost half of products has been exported to Europe, Japan and South-East Asia etc. As the excellent performance, the heat-pipe evacuated tubular collector not only can be used for producing hot water, also for air-conditioning and heating, melting of bitumen, desalination of sea water, and industrial process heating etc.

At present, BSERI is developing medium and high temperature solar collectors for more efficient utilization.

3.2. Solar Air-conditioner and heater

A solar powered absorption air-conditioning system with 100 KW cooling capacity was successfully constructed by BSERI in Rushan City, Shandong Prov., China. In addition to space cooling in summer, the system also can be used for space heating in winter and for domestic hot water supply in the whole year.

The system was installed on the Solar Energy Hall which is two-storey building with a construction area over 1000 m^2 and was architecturally designed to meet requirement of 540 m^2 solar collector placement. The system consists of evacuated tubular collector array, absorption chiller, cooling tower, water storage tanks, circulating pumps, fan-coil units, and auxiliary oil boiler and control system.

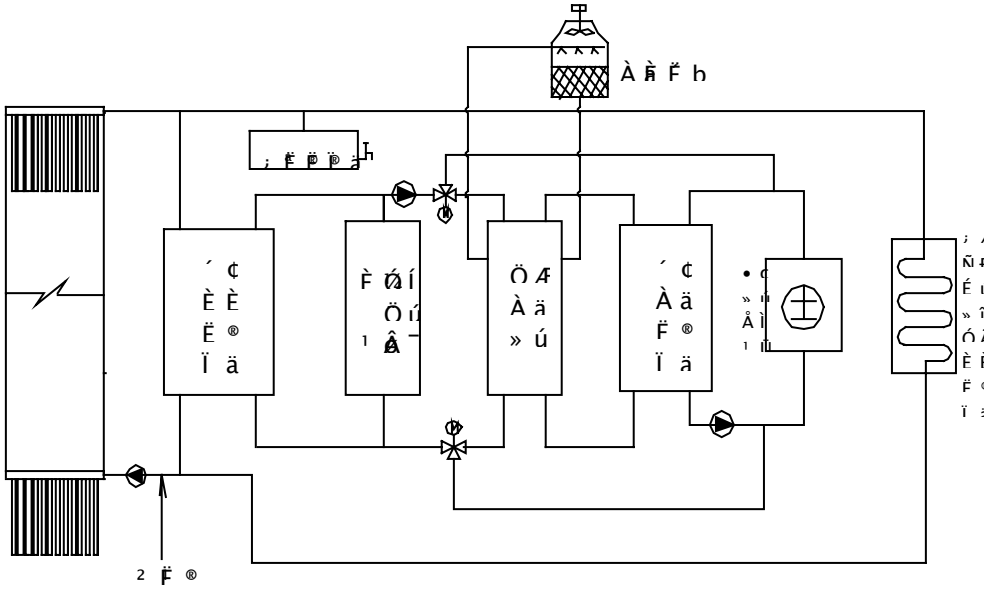


Fig3.solar absorption air conditioning and heating system

4. Innovation & Exhibition base of solar energy technology

The base will be set up by BSERI in the northern area of Beijing recently. An 120KW solar cell array and a solar air-conditioner

system with 500 KW cooling and heating capacity will be installed on the 9000 m^2 building, which will be designed thoughtfully to combine with solar energy utilization. The medium temperature solar collectors to improve thermal COP will power solar air-conditioner. Also the base will be equipped with advanced equipment and instruments in order to strengthen the ability for technology innovation and transfer of BSERI.

Fig 4. Innovation & Exhibition base of solar energy technology

5□Strengthen the international co-operation to push about the solar energy utilization in China.

In the past twenty years, many US specialists visited BSERI, we hope to strengthen this cooperation further. BSERI hope absorb advanced technology, also the invest to accelerate setting up 1 MW and 5 MW high efficiency solar cell production lines, also hope collect various solar cells for the exhibition of 120 KW solar cell array. We believe the cooperation will benefit both sides.